Smaller, Smarter C4ISR

Presentation to
Defense Science & Technology Seminar
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Director, DARPA

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Information Domain

“The transformation of the joint force to reach full spectrum dominance rests upon information superiority as a key enabler and [on] our capacity for innovation.”

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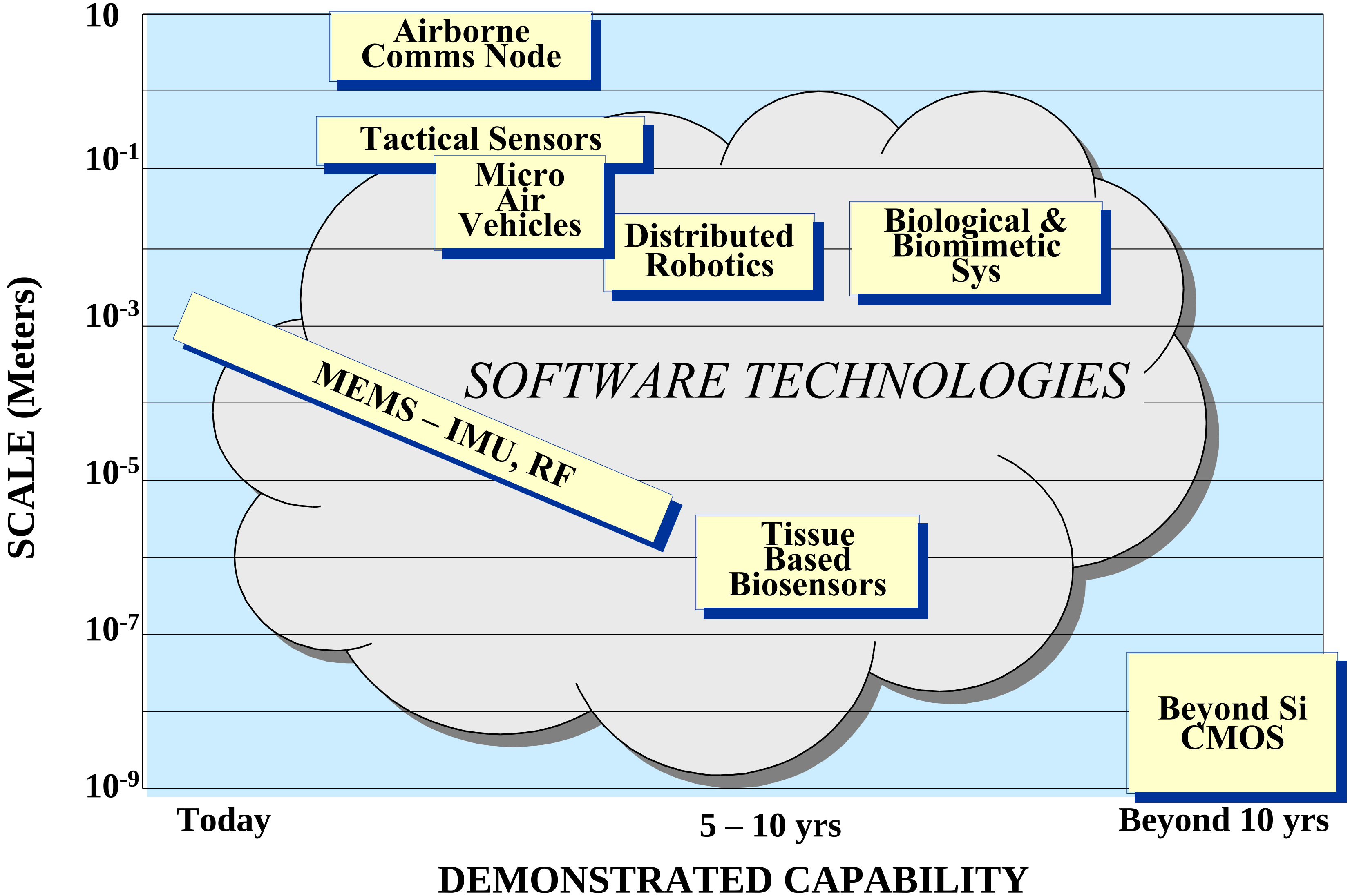
“Information superiority is fundamental to the transformation of the operational capabilities of the joint force.”

--Joint Vision 2020

DARPA Programs Aimed at Smaller, Smarter C4ISR



Tactical Sensors

- **Goal: Develop new sensor systems that can detect, track and classify mobile tactical targets and characterize fixed, man-made structures**
- **Challenges:**
  - **Computationally efficient algorithms to organize sensor field, detect, track, fuse, classify**
  - **Low-power, miniature sensor hardware & innovative deployment methods**
- ***Smarter & Smaller***
  - **Order of magnitude smaller volume**
  - **Low false alarm rate & small, low-power imaging systems**
  - **Use of collaborative signal processing across a sensor network**
- **Milestones**
  - **Visible camera launched from 40mm launcher to attach to concrete**
  - **Demonstrated 6 brassboard sensors performing precision targeting**
  - **End of this year: Increasing numbers of sensors in demos; launching IR and acoustic sensors from 40mm launcher**

Micro Air Vehicles

- Smallest military UAV – 45-in. wing-span
- DARPA has flown four families of proof-of-concept vehicles less 15 cm in size
  - 0.25 horsepower engine running on JP-8
  - 82 gram vehicle, 30 min. flight w/ color video sensor
- Plans are now to demonstrate an organic air vehicle for FCS in 15-75 cm size-range
  - Including sensor
  - Capable of autonomous flight, hover plus forward flight speeds of 50 mph

Distributed Robotics

- **Push robotics even smaller – less than 5 cm**
- **Use collective behaviors to optimize performance of robots with limited individual capabilities**
- **Develop software to allow swarms (100s!) of robots to operated collaboratively**
  - **Energy efficient communications among robots**
  - **Human robot interface to allow human to interact with robots collectively**
- **Milestones**
  - **Have 12 different robot efforts – roll, hop, swim, fly, reconfigure**
  - **Future: Demo sensors, actuators, comms to robots; Demo collaborative software**

MEMS for Inertial Navigation

- Ring laser and fiber optic gyros = ~ 30 cu in
- MEMS Inertial Measurement Unit = 10 cu in
  - Accuracy of <0.5 mg accelerometer bias and 1.0º/hr gyro drift rate
  - Temperature Range: -54 to 85ºC
  - Low Power: 1.0 Watt
  - Low Cost: $1,200
- Milestones
  - Demonstrated gyro operation at 1-100 º/hr
  - This year: Conduct brassboard testing with Wind Corrected Munitions Dispenser program office
  - Next year: Field test IMUs from three contractors

RF MEMS

- RF MEMS offers
  - High performance, low bias power consumption
  - Potentially low-cost manufacturing into a variety of substrates
- Size Reduction
  - x 53 in UltraComm Communication receiver; x 33 in weight
- Applications
  - Reconfigurable arrays, filters, tunable antennas, wearable antennas
- MEM-tenna: Very large electronically scanned radar antenna using MEMS phase shifters
  - 6 mo. – Demonstrate phase shifters
  - 30 mo. – Build array using 10,000 phase shifters

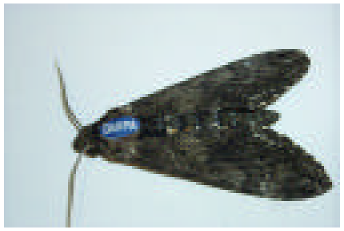
Airborne Comms Node

ACN is making our RF systems smarter – by combining communications and SIGINT into one modular package

- **Phase I (3 teams) started in FY98**
  - **Demonstrated narrowband, comms-only proof of concept**
- **Down selected to 2 teams for Phase II comms/SIGINT tech development and system design**
- **System design review - Jan. 02; Readiness review - Aug. 02**
- **Transition to Service with CDR-level design**

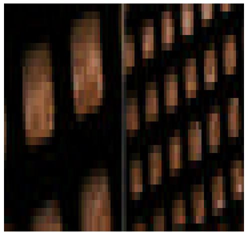
Biological & Biomimetic Systems

- **Goal: Explore unique capabilities of biological systems for defense – locomotion, sensory fusion, target location**
- **Thrusts: Living Systems as Sentinels --- Biohybrid Devices --- Biomimetics**
- **Accomplishments:**
  - Collected biological signals from living systems; used signals for animal sentinels, biohybrid devices, biomimetic platforms
  - Moving to field experiments; ideas taking hold in defense technology community
  - Demonstrated bees capturing BW simulant microbe
  - Trained and used living systems to ‘smell’ and detect UXO, BW
  - Used understanding of winged flight, legged locomotion, visual guidance/control to build robots

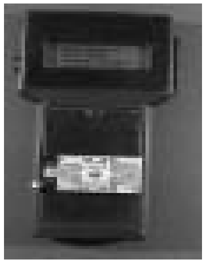


Tissue Based Biosensors

- **Program Goal:** Build an activity-based system able to detect known & unknown chem/bio agents
- **Current sensors can only detect & identify known agents**
- **Technical Approach:** Use the response of cells/tissues to detect the presence and toxicity level of threats



- **Milestones:**
  - **Extracted robust signatures of response for 'state change'**
  - **Improved operationally relevant stability of cells and tissues**
  - **Built handheld, bench-top prototypes and began field testing**
  - **Future: Add sample collection/preparation function and work on data acquisition/utilization**

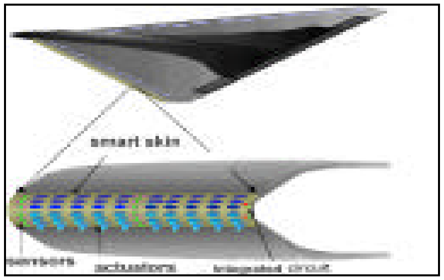


Embedded Software

Advances in processor, MEMS and photonics technology drive the deeper and finer grain integration of computing with physical processes

DARPA's response:

- **Integration of system and software design**
  - **Model-based design environments and model-based software generators for large avionics and vetronics applications by 2002 (MoBIES)**
  - **Automated design verification and validation approaches for hybrid systems by 2004 (SEC, MoBIES)**
- **New Composition Technology for embedded systems**
  - **Aspect-oriented programming languages and environments by 2003 (PCES)**
- **Revolutionary middleware for networked embedded systems**
  - **Composable, adaptive middleware for coordinating the operation of 10^2- 10^5 node MEMS applications by 2005 (NEST)**



Beyond Silicon CMOS for the Warfighter

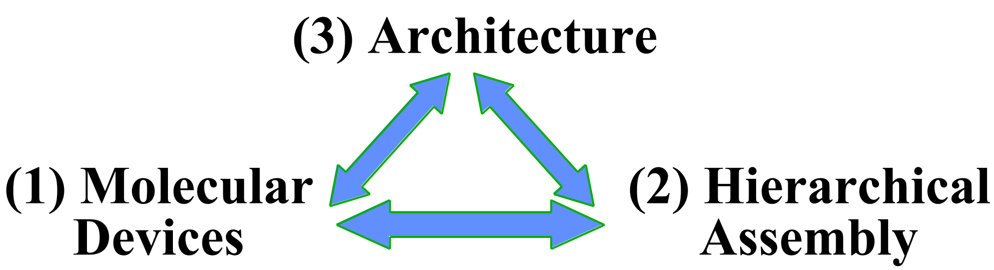
Powerful information technology devices and systems using approaches that extend beyond traditional CMOS scaling

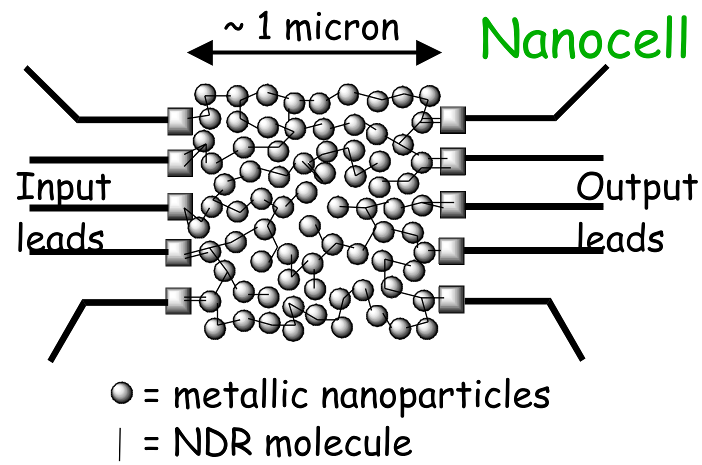
- **New design capabilities for information processing components leading to new ways of computing, sensing and actuation**
- **Examples: computational fabric, smart matter, quantum effects, bio-computing (DNA, molecular electronics, microbial robotics), spin effects**

Substantial reductions in size, weight, and power for reliable, fast and secure computing, communications, data storage

Example: Molecular Electronics

- **Goal: Create miniaturized computational engines and ultra-dense memory using self-assembled, functional molecules with connections to real world**
- **Accomplishments:**
  - **Demonstrated *room temperature* logic gates and scaleable 16-bit memories**
  - **Demonstrating initial attributes of scalability, gain, reversibility, interconnects, switching, multi-bit storage**
  - **Future: Demonstrate functional, scaleable computation *connected to outside world***





Summary

- **Information superiority is a key pillar of Joint Vision 2020**
- **DARPA programs are providing innovative smaller, smarter C4ISR technologies**

Today's S&T in C4ISR
will help enable
Full Spectrum Dominance